INTEGRATED LAND USE/AIR QUALITY/WATER QUALITY CONTROL STUDY

Sonoma County, California

INTERIM REPORT - Contract No. 68-01-2648

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I. INTRODUCTION

The purpose of the Integrated Land Use/Air Quality/Water Quality Control Study is to provide the Environmental Protection Agency with guidance concerning its air and water programs and the integration of these programs, particularly with respect to land use planning and control. To accomplish this purpose, it was necessary to carry out the study in a real world setting, in this case Sonoma County, California. As an equally important objective, the study should also provide Sonoma County and cities in the county with guidance that will aid in achieving and maintaining air and water quality standards.

The study has been organized in a form in which air and water quality impacts can be traced to specific land use policies, thus explicitly identifying the cause and effect relationships. As the first step in this process, land use powers and institutions are identified and groups of land use policies are selected for analysis. Next, a land use projection scheme is applied to translate these policies into probable land use patterns. The final stage of the project involves analyzing the alternative land use configurations in terms of air and water quality impacts.

This first interim/progress report is a summary of all work accomplished to date. The report is particularly decision-oriented in that the reasons for the important decisions are discussed in detail and background information for decisions not yet made is given.

The primary purpose of an interim report is information - to inform interested agencies and persons of the accomplishments to date in the study. But from the contractor's point of view, the most important aspect is feedback - to receive suggestions and criticism from persons and agencies that read this report. To

this end an attempt was made to include perhaps more detail than might be necessary to simply communicate the basic progress in the study.

The report begins with a discussion of the land use planning process as it exists today in Sonoma County. Agencies which influence land use, air quality and water quality are examined and an inventory of public actions with potential for affecting these three areas is provided.

The second major section of this progress report deals with the generation of alternative land use configurations. From these alternative development patterns will come the emission factors which are inputs to the air and water quality models. In this section the investigation of alternative land use allocation methods, environmental and land use data systems and the work of Sonoma County's Advanced Planning Division is summarized, followed by a discussion of the reasoning behind the selection of the methodology for generating the land availability data (the basic input to the land use allocation scheme).

The final section of the interim report outlines the research pertaining to air and water quality models. It begins with an evaluation of present air and water quality conditions in the County, followed by a review of the state of the art in air and water quality modeling. A summary of the persons and agencies contacted regarding these models concludes the report.

Progress on the study to date includes the following accomplishments:

- inventory of agencies influencing land use
- inventory of land use and environmental data
- review of land use projection methods
- review of air and water quality models
- development of methodology for generating alternative land use configurations

Major tasks to be completed in the near future include:

- detailed examination of land use policies and institutions
- selection of the land use policy combinations to be used for generating alternative land use patterns
- development of the land use allocation procedure for assigning projected population levels to 1-km grid squares
- selection of the air and water quality models to be used for evaluating the alternative land use configurations

II. INSTITUTIONAL/POLICY DIMENSIONS

A. Contact with agencies influencing land use, air quality and water quality

As a preliminary step in establishing the institutional context of the study, the agencies directly or indirectly influencing land use and the achievement of air quality or water quality goals in Sonoma County have been identified. A list of the agencies is included in the appendix. Section II(B) below describes the working relationships that have already been established with the planning departments of the county and municipal governments. Some contact has already been made with the other agencies (most notably the Local Agency Formation Commission, the Bay Area Air Pollution Control District, the North Coast Regional Water Quality Control Board, the San Francisco District of Corps of Engineers, and Region IX of the EPA). During the next month, the activities of all the agencies will be assessed in a more comprehensive way and related to the present processes of land-use development and environmental management.

B. Coordination with County and Municipal planning agencies in Sonoma County

A high priority has been placed on developing an understanding of the activities of the Sonoma County Advanced Planning Division, and establishing a basis for future cooperation. As the section of the county planning department responsible for the on-going general plan program, the Advanced Planning Division has a county-wide perspective and data base that promises to be of invaluable assistance to the success of this study.

The Division's organization and activities have been comprehensively surveyed and the completed components of the general plan reviewed. Repre-

sentatives of the project staff have been attending the meetings of the Division's Technical Advisory Committee and Citizens Advisory Committee to develop an understanding of the relationship of the Division's work to the concerns of the technicians and administrators of other county and local agencies, and to the views of county citizens. All of the members of the project staff have spent time at the Advanced Planning Division's offices becoming familiar with the data on hand, and the procedures used in generating the plan's finding and alternative proposals. A field office has been rented across the street from the Division's offices.

Lines of communication and cooperation have also been established with the County's Current Planning Division, and the planning staffs of Santa Rosa, Petaluma, Rohnert Park, and Cotati (the other municipalities in the county do not have planning staffs). The concerns and activities of these agencies have been assessed, their staffs have been informed about this study, and areas of potential mutual assistance have been identified.

C. Monitoring of land use dynamics

Several activities have been carried out with a view towards gaining an understanding of the dynamics of growth and land-use change and air and water quality maintenance in the county. A review has been made of the small number of available reports and analyses dealing with the subject. Additionally, the Sonoma County newspapers are being monitored for news about environmental management and planning and development related events, decisions, and issues. The continuing review of agency activities discussed in part II(A) will be supplemented by these monitoring and research activities.

D. Inventory of public actions with potential for influencing land use, air quality or water quality

A preliminary inventory has been made of the public actions that could potentially be applied in Sonoma County to influence land use, air quality, and water quality. Once the analyses described in parts II(A) and (B) have been completed, and the environmental conditions existing in the county outlined, an assessment can be made of the extent to which each of the potential strategies would be feasible or appropriate in Sonoma County. The major strategies that have been considered are summarized below.

<u>Strategies Focusing on Land Use</u>

1. Limitations on rates and ultimate levels of employment and population growth through policies analagous to those now being enforced in Petaluma which restrict the number of building permits which can be issued each year.

2. Channeling of new development into compact, easy to service urban areas by creating tightly defined urban expansion zones.

3. Application of regulations to modify the details of urban development.

    a. zoning

        - increases or decreases in allowed density
        - changes in parking requirements
        - regulation of the amount of impervious surface permitted
        - planting regulations
        - increased consideration of slope and hydrologic factors, and flood, seismic, and ground stability factors in zone designations
        - use of zone regulations to exclude new sources from selected "hot spots"
        - Use of zone regulations to exclude critical new sources from the planning area
        - use of zoning powers to foster the creation of environments appropriate for transit or automobile dependence

    b. subdivision regulations

- variations in requirements for services
- variations in the amount and character of open space that must be dedicated
- modifications in the design standards for the roadways that must be provided
- increase in design flexibility through Planned Unit Development provisions

c. environmental impact statement requirements

- increased use of EIS requirements as a lever to require modification of impacts in project design and development procedures

4. Regulation of the amount and character of non-municipal development.

a. regulation of the expansion or creation of water and sewer districts

b. restrictive zoning regulations for non-municipal areas - exclusive agricultural and forestry zones

c. stringent water availability requirements for rural residential development

d. performance standards for on-site sewage disposal

e. regulations of agricultural and forestry practices

5. Strategic Public Investment

a. Timing and location of highways and public transportation systems to reinforce growth policies

b. Timing, placement, and sizing of sewer and water systems

c. purchases of open lands to protect hydrologic systems, for wastewater disposal, or to buffer living and working areas from major sources of air pollution

d. urban renewal

e. land banking

6. Taxation and assessment policies

a. assessment based on present use, not potential for development

b. assessment based on legally designated use (i.e. if zoned as floodplain, assessment would reflect constraints on developability)

Strategies Focusing on Air Quality

1. emission density zoning
2. emission allocation
3. individual source-emission allocations
4. motor vehicle pollution control devices
5. inspection and maintenance of vehicular pollution control devices.
6. transportation control plans / parking management plans
7. hot-spot regulations
8. modifications in ambient air quality standards
9. roll-back requirements

Strategies Focusing on Water Quality

1. effluent discharge requirements for major point sources
2. non-point source discharge requirements - "best applicable technology" requirements
3. sewage treatment plant processing and discharge requirements
4. package plant regulations
5. stream quality standards
6. ground water quality standards
7. regulations for land disposal of sewage
8. regulations governing solid-waste disposal
9. septic tank limitations

III. DEVELOPMENT OF ALTERNATIVE LAND USE CONFIGURATIONS

A. Introduction

The generation of alternative land use configurations is of critial importance in this study since these configurations will serve as the basis for analysis in the air and water quality models. Emission factors will be developed for each projected land use, and these factors will become inputs to the air and water models.

After the Preliminary Work Plan was completed and presented to the EPA on October 24, 1974, a study was undertaken to investigate the potential applicability to this study of the multitude of land use projection schemes and data systems which have been utilized in past studies. This investigation included a full range of methodologies, from the basic "handicraft" approach to elaborate computerized coding and manipulation schemes. The ABAG staff was seeking to resolve two questions through this review of existing methods:

1. What is the most appropriate way to organize environmental and land use data for use in land use projections to estimate air and water quality?
2. What kind of predictive scheme should be employed to allocate land uses in the various scenarios?

After initial investigations of land use projection techniques, it was decided that a computerized system for allocating land uses in each scenario should be utilized because of the extremely large amount of information which must be evaluated and kept track of prior to each land use allocation in each scenario.

Though a decision had been made to use a computerized allocation scheme, the precise computer model still had to be chosen, and the form of the data inputs to the model had to be determined.

Land use allocation models rely on two basic types of data inputs--population and employment information and land availability data. The development of population and employment data is fairly straightforward since it is derived from numerical census data. The development of land availability data is not so simple, since it is based on spatial information of varying scales and levels of accuracy.

Two basic approaches for generating the land availability data for input to the allocation model were proposed:

1. A computer-based technique where each environmental and land use factor map is coded individually into a data bank and algorithms are developed to combine the basic data in different ways.
2. A manual technique where environmental and land use factor maps are physically superimposed and land availability (or capability) relationships are determined by inspection and manually recorded.

The following section summarizes the investigation of alternative land use allocation techniques, environmental and land use data systems, the work of Sonoma County's Advanced Planning Division, and the selection of the methodology to be used for generating the land use configurations, including the reasons for that choice.

B. Review of Land Use Allocation Methods

As mentioned in the introduction to this section, it was decided that a computerized land use allocation scheme should be used to allocate land uses in the various scenarios. Land use allocations will be based on a combination of population

and employment projections and land availability data [Land availability data will be discussed in detail in Sections II(C) - (F)]. A full spectrum of population and employment projections will be considered:

ABAG's Gronorth, Grosouth, and Losouth projections

Sonoma County Advanced Planning Division's projections

California Department of Finance (DOF) projections

The choice of projections to be used for each alternative will depend upon the particular constraints being tested. The projections will be adjusted to make them compatible with the land use policies. For example, high growth projections will not be applied in conjunction with severely restrictive environmental constraints. Both high and low projections will be considered in the analysis of most of the land use alternatives to provide information on the impact of the population level.

The following specific land use projection and allocation techniques were examined:

1. PLUM (Projective Land Use Model)

   The PLUM model disaggregates a region-wide population projection into sub-regional population and employment levels. It was developed by William Goldner, a consultant to ABAG and the Metropolitan Transportation Commission (MTC), and has been used in the Bay Area Simulation Study, the Bay Area Transportation Study, by MTC, and is currently being used by ABAG. PLUM disaggregates Sonoma County into 10 (soon to be 16) zones. These zonal projections would have to be further disaggregated into sub-zonal land use allocations. The size of these sub-zones has been chosen to be one kilometer, for the reasons outlined in Section II(F)(2).

2. ZAP (Zonal Allocation Procedures).

   The Washington-based firm of Peat, Marwick, Mitchell has written a series of programs which allocate broad-area projections to smaller sub-units (called zones). ZAP was developed for use with EMPIRIC, which is Peat, Marwick, Mitchell's equivalent of PLUM. ZAP has been applied in several areas to date, including studies in Atlanta, Central Puget Sound, Washington, D.C., and Denver.

3. DYLAM/Lakewood

   The City of Lakewood, Colorado in conjunction with the consulting firm of Parsons, Brinckerhoff, Quade and Douglas has developed a land use allocation model and applied it to Lakewood. DYLAM/Lakewood was designed to project land uses for each of approximately 1,000 40 acre grid cells. The model allocates land uses based on the "attributes" of each grid square and the relative desirability of these attributes to each land use.

4. In house

   An in-house allocation procedure could be completely written by the ABAG staff using in-house expertise and studies such as DYLAM/Lakewood for guidance. Such an approach would probably rely on PLUM or an equivalent model to provide sub-county population, employment and housing projections. These sub-county projections would then be broken down into 1-km^2 land use allocations based on a combination of of land availability and attractiveness factors. Land availability will be categorized into several classes depending on the severity of environmental constraints present. The attractiveness factors will

consider such elements as

- travel time to employment centers
- distance to major roads
- presence of sewer system and other infrastructure
- distance to service areas
- presence of visual and recreational amenities

The ABAG staff has tentatively decided to use PLUM combined with an in-house zonal allocation procedure. The allocation of land uses to the available land base in each scenario will be performed in an incremental process. The computer will allocate land uses for each of a set of incremental population and employment projections leading up to a target year projection. Current staff thinking is pointing towards increments on the order of 5 years, with a target year of around 2000.

C. Review of Computerized Environmental Data Systems

1. Tahoe Basin Study

The procedure used to evaluate land capability and development potential in the Lake Tahoe region was carefully examined by the ABAG staff. That process involved coding environmental information into 10-acre grid cells and manipulating this data with a computer.

Persons contacted concerning this study included Dr. Robert Twiss, Professor of Environmental Planning, U.C. Berkeley and project coordinator of the environmental impact evaluation; Walter Loew, computer programmer for the Tahoe study; and James Pepper, a former graduate student under Twiss and major participant in the Tahoe project. Pepper's thesis detailing the Tahoe study, entitled "An Approach to Environmental Impact Evaluation of Land-Use Plans and Policies: The Tahoe Basin Planning Information System" was reviewed, as was the manual for GRID, a computer program developed by the Harvard Center for Computer Graphics for manipulating and printing out data coded into grid cells.

2. Design Methods' Sonoma County Environmental Data System

Early in 1973 Sonoma County's Advanced Planning Division contracted with a computer consulting firm, Design Methods (now defunct), to digitize environmental data of the County into a 1-km grid system as part of the Open Space Element of the County's General Plan. These computer-coded maps prepared by Design Methods were studied in detail by the ABAG staff to assess their potential application to the EPA Integrated study. Issues addressed included level of detail coded, accuracy of the coding, information losses, additional data requirements and acceptability of coding rules. Bill Miller, the Design Methods project leader for the Sonoma Study, was contacted, and Dr. Twiss's review of the Design Methods' work, entitled "A Review of the Sonoma County Environmental Information System" was

examined.

3. Comarc's City of Petaluma Environmental Resources Management Project

   An investigation was made into the potential for using the techniques developed by Comarc Design Systems for computer coding environmental data into grid systems of various dimensions. Comarc has just recently completed an environmental inventory for the City of Petaluma at a 2 1/2 acre grid cell resolution. Time, cost and error factors involved in the coding process were examined. Of particular interest were the costs involved in coding slope and soils data, since these appeared to be the weak points in the Design Methods data set.

D. Review of Sonoma County Advanced Planning Divison Data and Methods

   The work of the Advanced Planning Division was carefully analyzed through a series of visits and phone calls to the Division's office. Material examined included the Environmental Resource maps; the Land Availability study; the Baseline Evaluation (the County's market trend projection to the year 2000), including Base Year data, employment projections, traffic analysis and allocation methodology; and the Sketch Plan Alternatives, including source data and allocation methodology.

E. Pilot Study to Compare Manual Overlay Method for Determining Land Availability to Computerized Method Based on Data Coded by Design Methods

   1. Description of Manual Overlay Method

      As discussed in the introduction to Section III, a two-part process for generating alternative land use configurations has been selected. The first part of the process, which will be accomplished by using either the manual overlay method or a computerized technique, calls for the production of land availability data for each of the grid cells in the

study area. The second part, which will be accomplished with the computer, involves the allocation of land uses to the available land base through the application of attractiveness factors.

In the manual overlay method, the land availability factors for each grid cell are determined by overlaying maps showing the various environmental and land use constraints that will be considered for each land use policy package. After all constraining factors have been traced onto a sheet of mylar, a grid is superimposed and the amount of unconstrained and partially constrained land remaining in each cell is estimated by eyeball inspection to 1/4 - cell resolution.

2. Pilot Study Methodology

A one week pilot study was undertaken to compare the relative merits of a manual overlay method for determining land availability to a computerized method using the data coded by Design Methods. It should be noted that a decision had already been made at this point to use a computer to allocate land uses in the various scenarios and to input the land availability (or capability) data to the computer in a 1-km grid system [See Introduction to Section III and Section III(F)(2)]. The question remaining to be answered was, should each environmental or land use factor be coded individually into 1-km grid cells or should these factors be superimposed beforehand (by overlaying a series of source maps) so that the coincidence of two or more factors in the same area could be incorporated into the coding. This question concerning the amount of overlap arises because there is considerable variation among certain environmental factors and land use types over a 1-km square area.

To begin the pilot study a test area of 100 1-km^2 cells was selected which contained a variety of environmental conditions and land uses. Then a sample set of land use policies was chosen (the same as in the County's Baseline Evaluation): land was unavailable for development in areas with slopes over 30%, floodplains, parks or existing development; land was readily available for development if within a sewer service area and not constrained by above factors; land was potentially available for development if unsewered and unconstrained.

A sheet of mylar was placed over each of the appropriate source maps and steep slopes, floodplains, parks, existing development and sewer service areas were traced onto it for the 100 cell test area. Then, percentages of land in each of the 3 land availability categories in each grid cell were manually estimated by "eyeball."

In the test of the computer method, the data coded by Design Methods was used. All cells in the test area which were coded with any of the 4 constraining factors or sewers were recorded on a gridded mylar sheet. This "computer-coded" sheet was then superimposed on the manually coded mylar sheet and a quick statistical analysis was made to determine the error involved in generating the land availability data via the computer method.

3. Statistical analysis of pilot study results

The purpose of the statistical analyses was to determine the error introduced by inaccuracies in the Design Methods (DM) 1-km^2 gridded data system. A major problem with the Design Methods data was the fact that most of the information was coded in an "all or nothing" form. In other words, a cell was coded either 100% flood plain (steep slopes, sewers, etc.) or no flood plain (steep

slopes, sewers, etc.) at all. Since it was felt that the accuracy of the DM coded cell designations could be improved by applying factors reflecting the average coverage of area coded, an attempt was made to develop these averaging factors prior to the undertaking of the statistical analysis. The procedure employed for this pre-statistical analysis preparation consisted of the following steps:

1. For each of the constrained cells (i.e., cells containing flood plains, slopes over 30%, parks or existing development) in the 100 cell test area, an estimate was made, to 1/4-cell accuracy, of the percent coverage of each constraint in that cell.
2. Based on the results from Step 1, a computation was made of the average coverage per cell for each constraint among cells containing that constraint.
3. For each cell containing a constraint, the difference between the average coverage and the actual coverage of each constraint was computed, thus yielding the amount of error per cell produced by using an average coverage factor.

The statistical analysis of the pilot study results considered only the 16 cells coded as flood plains, since the other constraints did not occur often enough to make a reasonable statistical analysis possible. Analyzing the portions of these cells which were coded as flood plains (to 1/4 of a cell resolution), it was found that the average error was .77 x 1/4, or 19%. The standard deviation was 1.0 x 1/4, or 25%. Thus, using the modified DM data, the estimates of percent of cell constrained would be off by an average of 19%, and 1/3 of the time they would be off by at least 25%.

The effect of this error factor on the air and water quality predictions are probably not great. The air and water quality point sources will be known precisely for major dischargers - and for water, municipal (non-runoff) and light industry wastewaters will be treated as point discharges. Regarding area sources, the error is tolerable for the purposes of this study. In particular, the errors tend to cancel as the kilometer cells are aggregated. Since oxidant levels will be determined from emissions mixed over several square kilometers this factor will be relatively insensitive to 20% grid emission errors. Runoff will be more sensitive but will be compatible with the accuracy expected from the model. Carbon monoxide level prediction will be the most severely affected and, again, a 20% error will probably not invalidate comparisons among alternatives. Water runoff quality factors are generally known to less than 20% accuracy.

F. Selection of Methodology for Generating Land Availability Data

After completion of the pilot study and statistical analysis, a decision was made to use the manual overlay technique to generate the land availability information for input to the computerized allocation program. This decision was arrived at for the reasons outlined in the following section.

1. Reasons for selecting manual overlay method

<u>Overlap Sampling</u>

Using Design Methods (DM) coded data for estimating land availability for each grid cell would necessitate a time-consuming process of manually checking the amount of overlap between the various environmental

development and infrastructure factors coded in the DM grid cells. The amount of overlap occurring in each grid cell is a critical factor in the determination of the per cent of a cell with growth constraints, since the average size of most environmental and land use types is much smaller than 1-km^2 (250 acres). For example, if constraining factors generally overlap, then portions of the cells will be left unconstrained (and constrained parts of cells will be constrained by several factors simultaneously) -- but if there is no spatial correlation between constraints, then greater portions of the cells will fail(on only one constraint), leaving less of the cell unconstrained for development.

Determining the overlap factors would actually require a manual overlay analysis of the entire region combined with a sampling procedure and statistical analysis, for each alternative.

Averaging Effects

The process of applying average overlap factors in the computerized land availability analysis would have the effect of smoothing out the allocation of growth over a broader area by creating land availability where it does not exist and reducing land availability where it does exist. The pilot study indicated that for constraints such as floodplains, emissions are spread over a broader area and hot spots reduced. In the case of the constraint of existing development, the effect is reversed: higher growth is allocated to built up areas and lower growth allocated to the urban fringe. Again, this is due to the assignment of average cell constraints. All cells are coded as, e.g., 75% developed and therefore capable of sustaining 25% more growth. So the denser areas will receive more growth than there is actually room for and vice versa.

Since the statistical analysis of the pilot study indicated that the error resulting from the use of average coverage factors would be tolerable, the "averaging effect" argument by itself did not justify abandoning the Design Methods' data.

Reliability of Coded Data

Serious deficiencies and inaccuracies were found to exist in certain of the key coded data maps. Since the accuracy of the entire land availability study will heavily depend on the accuracy of this basic data, an extensive amount of recoding would be required to prevent excessive error factors from resulting.

The slope and soils maps appeared to be the most unreliable of the Design Method's data set. Slope and soils information was a problem because each discrete slope and soil type tended to be far smaller than 1-km^2. In the case of the slope map, many of the flatter areas dropped out because the steeper slopes in a cell were usually coded. The soils map had several serious problems. In this map soil types were grouped into soil series and one series for each cell was coded. Based on Twiss's sampling observations, there were an average of 5 different soil types and 4 different soil series in each cell. There was also the question of the registration of the original source maps with the grid overlay. The soils information was coded from the original soils maps on air photos, which are highly distorted away from their centers. Since these maps were taped together and then overlain by a grid, the lack of cell registration was amplified. Bill Miller, the former Design Methods project leader (now of Dames & Moore), has estimated the accuracy of the soils map as ± 2 km, calling it the most unreliable of the set. Since soils information forms the basis of many environmental constraints (such as septic tank suitability, high water table, soil stability and bearing capacity), it seemed to be a risky venture to embark on an approach which would depend heavily on information of very questionable accuracy.

Credibility

The Design Methods data base was developed for an open space plan which received considerable adverse reaction. As a result, residents of Sonoma County tend to look askance at projects using this data.

The Other Viewpoint

The argument for the computerized method is the flexibility which an automated system yields in considering a larger number of alternatives. There is a 5,000 cell area to be analyzed and then manually entered as computer-usable data. Optimization of strategies is greatly facilitated through the use of multiple runs, and since the other parts of the study will or can be automated, this aspect will be the weak link regarding time required.

It should be noted that though a decision has been made to begin the study using manual method to generate land availability data, there is still a possibility that a computerized technique may be employed for this purpose at a later date if the deficiencies in the computerized system can be eliminated or are shown unimportant. Research is currently being undertaken into the feasibility of recoding the inaccurate data. Although the computerized technique would not replace the manual method, it might be a useful tool to generate variations upon the basic alternatives. It might also be appropriate for use in the outlying areas of the county which will not face intense development pressures.

2. Reasons for Choosing 1-km Grid as Basis for Land Availability Calculations

Conformance with Models

Carbon Monoxide

Since area-source air quality models use a square (or rectangular) grid, this simple geometry contains the advantage that a conversion will not be necessary, as would be the case with, e.g., traffic zones. The size was chosen as a maximum for which a CO analysis would be useful--averaging over larger cell size, the effects of certain high traffic areas would be too diluted. Equally important, a previous air quality study in Marin County[1] has shown that for conditions expected in this study, CO violations can be seen averaged over an area as large as 1 km^2.

Oxidant

Since oxidant does not form until several km from the hydrocarbon emission, by which time the emissions have horizontally diffused to typically several hundred meters, thereby mixing adjacent cell contributions, it is felt that a 1-km^2 resolution is sufficient.

Surface Runoff

Urban runoff has been computed at rather finer detail than 1-km^2. In this study, the detailed slope-soil information will have to be combined with average runoff emission factors of 1-km^2 resolution. This, however, is appropriate for the conventional technique, since the runoff factors tend not to vary as fast as the physical characteristics, and are disaggregated by type into very broad categories. Consequently, the use of 1-km^2 grid cells is not expected to increase the uncertainty greatly over a more detailed grid.

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[1] Bay Area Air Pollution Control District, 1972, "A Study to Assess the Impact of Growth Upon the Air Quality of Southeastern Marin County."

Previous rural work[1] has used a basin size of 5-8 km^2 (2 - 3 mi^2) as a minimum basin size in rural areas. Aggregating land use to 1-km^2 will enable representative proportions of each use in the basin to be included. A problem may arise correlating detailed slope-soil information with land use on a 1-km^2 grid, to determine runoff. Estimates will be made of the uncertainty introduced, but as in the urban case, the increase is not expected to be great.

Ease of "eyeball" Estimations

Eyeball estimations of the percent coverage of various environmental and land use factors in a region can most easily be done with a small-scale, uniform unit, with simple geometry such as a 1-km square cell. Estimations of coverage for a larger-scale cell would probably require the aid of a finer grid overlay as an interim step, because it is difficult to quickly estimate the total area of many small, odd-shaped parcels.

Possibility of Using Design Methods' Data

It is possible that some of the data which Design Methods coded could be used in the outlying areas of the County, where fine-grained detail is either not necessary or not available. For example, the manual method could be used to determine land availability factors for the Santa Rosa Plain, and the DM data could be used directly for the rest of the County. This flexibility in use of source data would be possible only if the handicraft data is coded for a 1-km cell size. There is also the possibility of using the DM data to generate variations on the

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1 Water Resources Engineers, 1973, "Application of the EPA Stormwater Management Model to Agricultural Watersheds for the Iowa-Cedar River Basins," an Intermediate Technical Report, prepared for the Environmental Protection Agency, Systems Development Branch, Washington, D. C. 20460, Contract No. 68-01-0742.

handicraft determinations of the basic alternatives. This option will be preserved through the use of 1-km grids.

G. Summary of Persons and Agencies Contacted

Subject	Person/Agency Contacted
PLUM	Dr. William Goldner Consultant to ABAG/MTC
ZAP/EMPIRIC	Dr. Richard Worrall Peat, Marwick, Mitchell & Co. Washington, D.C.
Tahoe Study	Dr. Robert Twiss Professor of Environmental Planning University of California, Berkeley
	James Pepper Former Graduate Student in Landscape Architecture under Twiss (Now Assistant Professor at University of California, Santa Cruz.)
	Walter Loew Computer Programmer for Tahoe Study (Now at University of California, Davis)
Design Methods' Coded Data	Bill Miller Project Leader of Sonoma Study for Design Methods (Now at Dames & Moore, Los Angeles)
Computer Digitized Data	Ron Walters President, Comarc Design Systems San Francisco, California
	Frank Gray Director of Community Development Petaluma, California
Sonoma County Environmental Resource Maps, Baseline evaluation, Sketch Plan Alternatives, Design Methods' data	Sonoma County Advanced Planning Staff Santa Rosa, California

IV. AIR AND WATER QUALITY MODELING

A. Evaluation of present air and water quality and modeling requirements of the study

1. Air Quality

Air Quality in Sonoma County at the present time is generally good. The Santa Rosa area has an incipient oxidant problem, as evidenced by the 8 pphm* Federal 1-hr. standard being exceeded 5% of the days from July to December in 1972, and experience gained from a Bay Area Air Pollution Control District study in adjacent Marin County indicates that certain growth patterns might cause future CO violations in the urban centers, again notably Santa Rosa. The area is meteorologically conducive to concentrations of high pollutants, and it is the current low emission levels, coupled with frequent prevailing northerly winds which tend to flush the valley, that cause the low concentrations observed. Due to the absence of heavy industry and power plants, particulates and SO_2 are not considered a problem; but certain rural point sources, such as saw mills, may cause localized problems. Finally, NO_x does not appear to be a problem in the area, but NO_2 emission projections would be needed to predict future photochemical oxidant concentrations.

From the preceding we see that CO and oxidant will be the most important considerations in the county air quality. SO_2 and particulates, on the other hand, will be important only as point sources. Table 1 summarizes model requirements.

*pphm: parts per hundred million

TABLE I

Pollutant	Source[4]	Source configuration	Is pollutant reactive?[5]
CO	vehicles combustion industrial process	area, line point, area point, area	No
Oxidant[1] (RHC)	vehicles industrial process	area, line area, point	Yes
Particulate[3]	industrial process combustion vehicles	area, point area, point area, line	No
SO_2^3	industrial process combustion diesel fuel	area, point line	No[2]
NO_x	vehicles, combustion	area, line area	Yes

2. Water Quality

Although the condition of the surface waters in Sonoma County is generally very good, water quality problems exist, including high nutrient levels leading to algal blooms, low dissolved oxygen (D.O.) concentrations and sediment runoff. The critical nutrient and D.O. situations arise during the low flow summer months and are caused primarily by sewage treatment plant (STP) effluents and dairy operations, particularly in the Laguna de Santa Rosa area. These inputs tend to cause high algal growth in the lower Russian River,

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[1]In this table, sources of oxidant actually refer to reactive hydrocarbons (RHC). Hydrocarbons are not considered a separate pollutant in this work.

[2]SO_2 would be considered non-conservative in a photochemical model, but is usually analyzed as conservative in point sources.

[3]SO_2 and Particulate are considered less important problems than CO and Oxidant.

[4]Underlined sources are the most important.

[5]Certain pollutants are conservative (non-reactive); others are reactive and more difficult to model.

with a similar situation tending to occur in Bodega Bay. Construction, certain agricultural and silvicultural practices, e.g. replacement of forest lands by sheep grazing pastures, and gravel operations tend to cause high sedimentation during periods of high flow. This situation will be altered if proposed dams are constructed. Also, low D.O. levels in Santa Rosa Creek and the Petaluma River reflect, in part, contributions from urban runoff. Many parts of the county tend to have clay soils and high water tables, particularly in winter, which cause pollution from individual disposal systems such as septic tanks to reach surface waters, notably manifested in high coliform counts. As a result, the North Coastal Regional Water Quality Control Board is considering stringent regulations for such systems. The groundwaters are generally quite good, with local exceptions. Surface pollutants tend to run off rather than infiltrate, and there is presently little irrigated agriculture.

From the above discussion we see that we have four aspects of water quality to consider:

- Point discharges to surface waters
- Urban runoff
- Rural (agriculture, dairy) runoff
- Groundwater considerations

There exists a range of standard modeling techniques for the first two problems, but considerable effort was necessary to assess modeling capabilities for the latter two. Also, in addition to the present and projected water quality problems, the models should have the versatility to respond to problems which might arise if expected land use and water quality mitigation controls are not enacted, or if land use develops in unanticipated directions.

B. Assessment of air and water quality models

1. Air quality models

There is a wealth of tested models available to model carbon monoxide (CO). Table 2 lists some of the more widely known models and techniques. For the purposes of this study, an area source CO model is necessary and probably sufficient, as the emphasis is not on local air quality violations caused by individual facilities. Modeling oxidant, on the other hand, is a considerably more involved enterprise. Simple approaches often cannot cope with the problem due to the reactive nature of the constituents. The more rigorous comprehensive models can be expensive to run, require detailed input data and have not been thoroughly tested, especially in the Bay Area. Nevertheless, oxidant concentrations must be addressed in this study due to their importance in the Bay Area and their regional (as opposed to local) nature. Possible approaches are use of a modified Gifford-Hanna model, a procedure that is very new and untested; a rollback model, which does not provide spatial resolution or account for constituent reactions; or a simplified reactive hydrocarbon (RHC) model which treats RHC's as conservative and assumes a correlation with oxidant, an approach which is not very accurate.

At the present time, the modified Gifford-Hanna approach of the Bay Area Air Pollution Control District (BAAPCD) seems to be best for CO modeling in terms of the needs of this study, one of which is coordination of efforts with the District. The approach for modeling oxidant will be determined in the future, and the statistical analysis relating long term average concentrations to the shorter averaging times on which the CO and oxidant standards are based will utilize the Larsen log-normal distribution method.[1]

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[1] Larsen, R. I.: A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards, EPA Pub. No. AP-89, 11/71.

TABLE II

Model	Computer time required	CO or Oxidant capabilities	Applicable Emission source configuration
APRAC-1A[1]	relatively fast	CO	line sources, and background on 25 X 25 grid
Gifford-Hanna[2]	relatively fast	CO, possible modification for oxidant	area as virtual point sources, point
AQDM[3]	moderately fast	CO	point area as virtual point
CDM[4]	moderate	CO	point, area
Photochemical Diffusion Models:			
DIFKIN[5]	moderately slow	All	Area (trajectory approach)
SAI[6]	Long (but only CO run would be faster)	all	area (Grid approach)
LLL[7]	Long	all	area (Grid approach) [Not presently available]

[1]Marcuso, R.L. and Ludwig, F.L.: "User's Manual for the APRAC-1A Urban Diffusion Model Computer Program," Prepared for the Coordinating Research Council and EPA, Contract CAPA-3-68 (1-69), Stanford Research Institute, Menlo Park, CA.

[2]Gifford, F.A., Jr., and Hanna, Steve R., 1971: "Urban air pollution modeling," Proc. 2nd International Clean Air Congress, Edited by H.M. Englund and W.T. Berry, Academic Press, New York and London, 1146-1151.

Gifford, F.A., Jr., and Hanna, Steven R., 1972: "Modeling urban air pollution", Atmospheric Environment 7, 131-136.

Hanna, Steven R., 1971: "A simple method of calculating dispersion from urban area sources", J. Air. Poll. Contr. Assoc., 21, 774-777.

Hanna, Steven R.: "Application of a Simple Model of Photochemical Smog," Proceedings of the 3rd Clean Air Congress of the International Union of Air Pollution Prevention Association, Dusseldorf, Germany, Oct. 8-12, 1973.

[3]TRW Systems Group, 1969: Air quality display model, Prepared for Department of Health, Education, and Welfare, Public Health Service, Consumer Protection and Environmental Health Service, National Air Pollution Control Administration, Washington, D.C., Contract No. Ph-22-68-60. (Available from NTIS, Springfield, Va., 22151 as PB-189-194)

[4]Calder, K.L. "Mathematical Modeling of Air Quality Through Calculation of Atmospheric Transport and Diffusion," Proceedings of the Third Meeting of the Expert Panel on Air Pollution Modelling, CCMS/NATO, Paris, France. (Oct. 2-3, 1972).

User's Guide to the Climatological Dispersion Model by Adrian D. Busse, John R. Zimmerman, 12/73, EPA Environmental Monitoring Series (EPA-R4-73-024), for an appendix describing and comparing 2, 3, and 4, and suggesting some modifications to 2.

[5]Eschenroeder, A.Q. and Martinez, J.R.: "Further Development of the Photochemical Smog Model for the Los Angeles Basin," General Research Corp. GR-1-191, 3/71.

Martinez, J.R.: User's Guide to Diffusion/Kinetics (DIFKIN) Code, EPA Environmental Monitoring Series (EPA-R4-73-012 b), 10/72.

[6]Reynolds, S.O. et al: "Mathematical Modeling of Photochemical Air Pollution," Atmospheric Environment 7, 1033-1061.

[7]Knox, J.B. et al: Development of an Air Pollution Model for the San Francisco Bay Area Second Semiannual Report, Lawrence Livermore Laboratory, UCRL-51537, 2/74.

Coordination with Bay Area Air Pollution Control District

ABAG will be working jointly with the District on the analysis of air quality. The District and Sonoma County have already drawn up an arrangement whereby the County will submit a 1-km square gridded emissions inventory to the District, which will analyze the emissions and predict pollutant concentrations. Initially the intention was to apply this procedure to the alternative plans (or the preferred alternative) generated by the county comprehensive planning effort, but this work has been postponed in order to incorporate it into the ABAG study, which might develop a more automated analysis procedure and consider a wider range of pollutants. Whether this is necessary will be determined during the next month. The District is willing to jointly supervise a contracting effort to perform the modeling, as the person power demands on its staff are already high. In particular, the analysis procedure currently used by the District, a Gifford-Hanna approach, possibly does not adequately address the problem of photochemical smog.

Assessment of vehicle kilometers of travel (VKT)

Sonoma County Advanced Planning Division has contracted JHK & Associates, of San Francisco, as transportation planning and analysis consultants for the general plan. JHK has constructed a link-node road network which includes most paved public roads in the county, with link distance to hundredths of miles and a vehicle speed for each link. The California Department of Transportation has offered their program which converts link-node vehicle emissions information into gridded vehicle emissions. A meeting is scheduled for the end of November among ABAG, Sonoma County and JHK, and the Bay Area Air Pollution Control District to begin working on those matters.

2. Water quality models

The state of the art in runoff modeling is still in its infancy. Although much theoretical work has been done, practical applications involve either an expensive and laborious consideration of the specifics of each situation or a level of generality which produces results of less applicability to a situation than might be desired or necessary. This situation is particularly acute in the non-urban situation, where the hydrology tends to be complicated by the different levels of soil perviousness and moisture retention. One approach to circumvent this problem is studying certain representative basins in detail to formulate generalizations, and then applying these to the other basins in the county. The generalizations will themselves be valuable.

The EPA-funded Storm Water Management Model[1], and the descendants of the Stanford Watershed Model[2], have both been modified for certain rural applications, and would be applicable to our study. One requirement that is evident from the above is the necessity to consider both high and low flow conditions. Runoff is not currently a problem during low flow, since there is not much irrigated agriculture in the county at this time. As a result, a simple stream model will be applicable for the summer months. This model must consider more than D.O. and conservative substances, however, as eutrophication is a problem in the area. An applicable model would be QUAL-II.[3]

[1]Metcalf & Eddy, Ind., University of Florida, and Water Resources Engineers, Inc.: Storm Water Management Model, EPA Report 11024 DOC 07/71, 4 vol., 10/71.

[2]Crawford, N.H. and R.K. Linsley. Digital Simulation in Hydrology: Stanford Watershed Model IV, Stanford University, Palo Alto, CA, Department of Civil Engineering, Technical Report No. 39, July 1966.

Hydrocomp International, The. Hydrocomp Simulation Programming--Operations Manual. Palo Alto, CA, February 1972.

[3]Texas Water Development Board, Austin, Texas: QUAL-I-Simulation of Water Quality in Streams and Canals - Program Documentation and User's Manual, NTIS No. PB202-973. 9/70

Water Resources Engineers, Inc., Austin Texas: Computer Program Documentation for the Stream Quality Model Qual II, Prepared for EPA, Contract No. 68-01-0708, 10/73.

C. Summary of persons and agencies contacted

Air Quality

Subject	Persons/Agencies Contacted
Air Quality & Air Quality Problems	Bay Area Air Pollution Control District EPA - Region IX
Modeling	Bay Area Air Pollution Control District EPA - Region IX Reg. Meteorologist Photochemical Modeling Seminar EPA - Model Applications Branch RTP, North Carolina California Department of Transportation San Francisco, Sacramento Systems Applications, Inc., (SAI Model) San Rafael, CA Stanford Research Institute (DIFKIN model) Livermore Radiation Lab (LLL model)
VKT (VMT) Calculations	Sonoma Co., Advanced Planning Div. Consultant: JHK, Inc., San Francisco Metropolitan Transportation Commission ABAG Analysis Division
Emission Factors	Bay Area Air Pollution Control District California Air Resources Board - Land Use Planning Program

Water Quality

Subject	Persons/Agencies Contacted
Water Quality & Water Quality Problems	EPA - Reg. IX California State Water Resources Control Board - Planning Div. North Coastal Regional Water Quality Control Board San Francisco Bay Regional Water Quality Control Board Sonoma County Advanced Planning Division Water Resources Engineers, Inc. Walnut Creek, CA - Contractor for Basin Plans Brown & Caldwell Walnut Creek, CA "

Subject	Persons/Agencies Contacted
Modeling	EPA - Planning Assistance Br. Water Planning Div. Washington, D.C. California State Water Resources Control Board - Research Div. Hydrocomp, Inc., Palo Alto, CA (Stanford Watershed Model) Water Resources Engineers, (EPA Stormwater Management Model) Walnut Creek, CA
Agricultural Runoff	EPA - Reg. IV EPA - Athens, GA Research Facility EPA - Ada, Oklahoma NERC (Dr. Art Hornsby)
Groundwater	EPA - Region IX Brown & Caldwell, Walnut Creek, CA
Relationship between Land Use and Air Quality	Dr. Walter Spofford (Resources for the Future, - Washington, D.C.) Dr. Tom River (with Walter Isard-U. of Penn.) Dr. Phillip Patterson EPA - Urban Modeling

V. APPENDIX

PRELIMINARY LIST OF AGENCIES INFLUENCING AIR QUALITY, WATER QUALITY, AND LAND USE IN SONOMA COUNTY

LOCAL AGENCIES

Cotati

Planning - Mrs. Susan Boehlje 201 W. Sierra	795-5478
Public Works Department 7790 Old Redwood Highway	795-7281

Healdsburg

All offices at City Hall, 126 Matheson St.	433-4466
Sanitation Department	
Water Department	

Petaluma

All offices at the Petaluma City Hall, Post and English Streets	
Planning - Frank Gray, Director	763-2613
Water District	"
Sanitation Department	"

Rohnert Park

All offices at the municipal buildings, 6750 Commerce Boulevard	796-5416
Planning - Paul Skanchy	
Sanitation Department	
Municipal Water Department	

Santa Rosa

All offices at the Santa Rosa City Hall,
100 Santa Rosa Avenue

City Bus Line	528-5306
Planning - David Baker, Director	528-5216
Public Works	528-5141
Sewer Department	528-5254
Water Department	528-5231

Sebastopol

All offices at City Hall, Bodega Highway	823-6446

Sanitation Department

Water Department

Sonoma

Water Department
City Hall, 1 The Plaza

Other Sub-County Entities

Centralized administration for sanitation districts serving Forestville, Occidental, Sonoma Valley, and South Park 2555 Mendocino Avenue, Santa Rosa	527-2351
Sonoma County Airport Sanitation Dept.	542-3139
Windsor County Water District 9077 Windsor Road, Windsor	838-6552

COUNTY AGENCIES

Local Agency Formation Commission 2555 Mendocino Ave. Santa Rosa David Dorfman, Director	527-2431

Planning Department

Current Planning 2555 Mendocino Ave. Santa Rosa	527-2931
Advanced Planning 2979 Cleveland Ave. Santa Rosa	527-2864

Public Health Services

1313 Channate Road, Santa Rosa Environmental Health/Septic Tanks	527-2711
Northern Sonoma County Air Pollution Control District	527-2853
Sonoma County Assessor 2555 Mendocino Ave. Santa Rosa	527-2541

Pulbic Works Department

2555 Mendocino Ave. Santa Rosa	527-2231

Water Agency

2555 Mendocino Ave. Santa Rosa	527-2211

STATE AND REGIONAL AGENCIES

Comprehensive Planning

California Office of Planning and
Research
1400 Tenth Street
Sacramento

Association of Bay Area Governments Claremont Hotel Berkeley	841-9730

Areas of Special Concern

Bay Conseration and Development Commission 30 Van Ness Street, San Francisco	557-3686

California Coastal Zone Conservation Commission 472-4321
North Coast Region
1050 Northgate Drive, San Rafael

Russian River Interagency Task Force
Glen E. Delisle
The Resources Agency
1416 Ninth St. Sacramento

Transportation

Metropolitian Transportation Commission 849-3223
Claremont Hotel
Berkeley

Caltrans, District IV 557-1840
150 Oak St.
San Francisco

Golden Gate Bridge, Highway, and Transportation District 346-5858
Administration Building, Toll Plaza
San Francisco

Air Quality

California Air Resources Board
1025 P. Street, Sacramento

Bay Area Air Pollution Control District
939 Ellis St. San Francisco

Water and Water Quality

California Department of Water Resources
P.O. Box 388, Sacramento

California Water Resources Control Board
1416 Ninth St., Sacramento

Regional Water Quality Control Board
S. F. Bay Region
1111 Jackson St. Room 6040
Oakland

Regional Water Quality Control Board
North Coast Region
2200 County Center Drive, Suite F
Santa Rosa

Bay Area Sewer Services Agency 548-7600
Hotel Claremont
Berkeley

Other Agencies

California Division of Forestry 542-1331
North Coast District Headquarters
135 Ridgeway Ave., Santa Rosa

California Parks and Recreation Department 542-7190
District 2 Headquarters
1621 Cleveland Ave., Santa Rosa

FEDERAL AGENCIES

EPA Region IX 556-2320
100 California St., San Francisco

Corps of Engineers 556-2291
San Francisco District
100 McAllister, San Francisco

Russian River Comprehensive Study 556-8537
Radford Hall, Manager

Department of Transportation
450 Golden Gate Ave. San Francisco

Federal Highway Administration
450 Golden Gate Ave. San Francisco

Urban Mass Transportation Administration
450 Golden Gate Avenue

Department of Housing and Urban Development

Regional Office, Region IX
450 Golden Gate Ave. San Francisco

U. S. Soil Conservation Service 544-1330
2544 Cleveland Avenue
Santa Rosa

Bureau of Land Management